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PROCESSING OF ERTS-1 MULTISPECTRAL DATA OF INDIA

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Report 193301-4-L

February 1973

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1.0 INTRODUCTION

In the fall of 1972, the Environmental Research Institute of Michigan (then Willow Run Laboratories of the University of Michigan) undertook computer processing of ERTS-1 multispectral scanner data of India. The processing was performed to demonstrate that useful pattern recognition could be performed on data that had first been tape recorded in the satellite, then transmitted to the ground. A second goal was to attempt to generate land use maps of an area with sizably different cultural practices from those found in the United States.

2.0 AREA SELECTED FOR STUDY

The first step in processing was to obtain imagery from the EROS Sioux Falls Data Center. The image sets were then examined to get a first look at data quality, to select cloud free data for analysis, and to select an area generally familiar to Dr. Sharma. This latter requirement was important, since at least a general knowledge of land use practices would be required for subsequent digital computer processing.

After considerable deliberation, a portion of ERTS frame 1043-04562 was selected for analysis. The frame, with intensive study area outlined, is shown in Figure 1. The map of Figure 2 shows the area of the frame and the intensive study area. Figure 1 shows the low, generally humid area of northwestern India just west of Delhi. The bright area to the upper right of the frame is the foothills of the Himalaya Mountains. These mountains appear

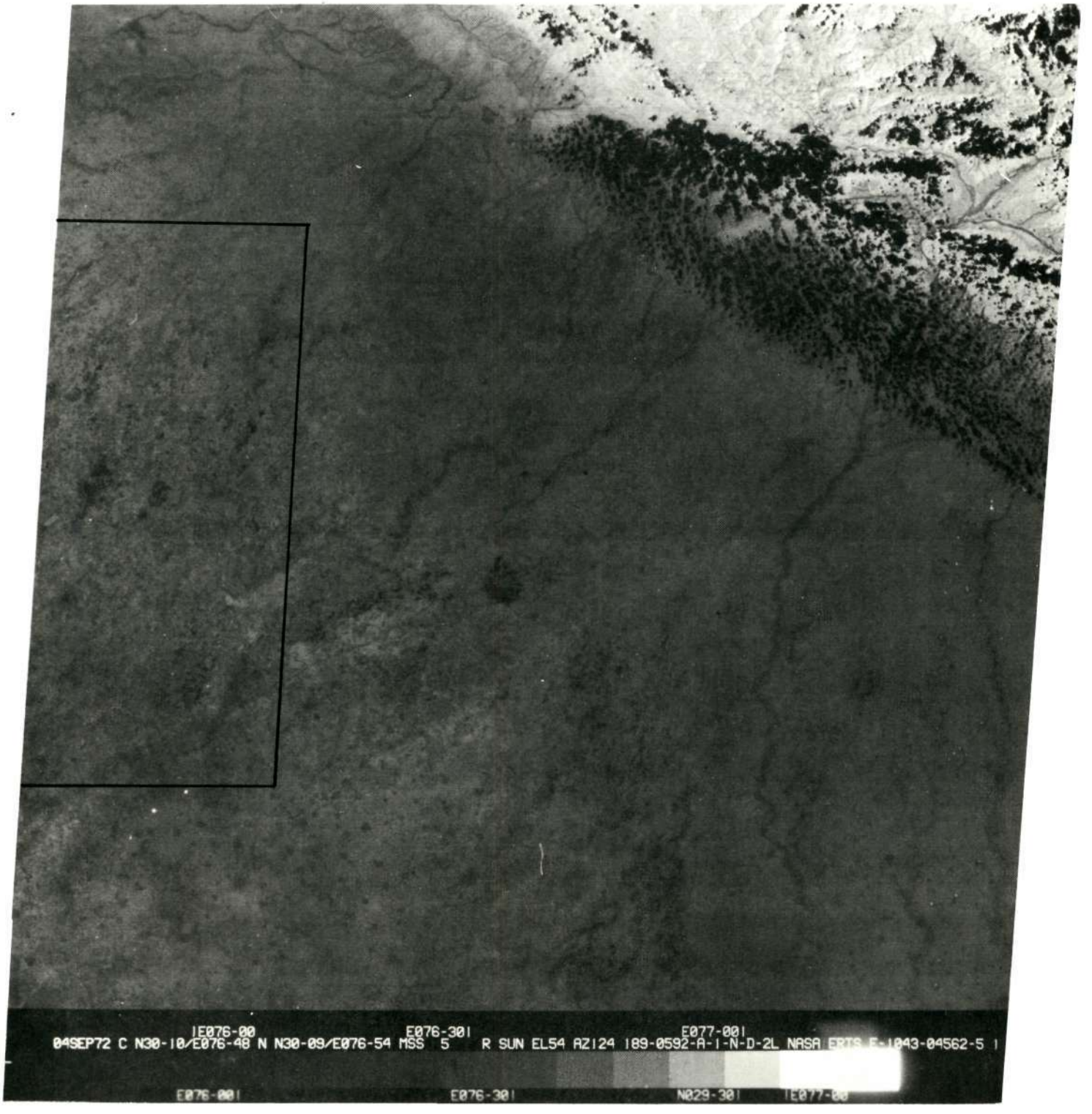

FIGURE 1

NEGATIVE PRINT OF BAND MSS-5 FOR
INDIA AGRICULTURE TEST AREA (FRAME 1043-04562)

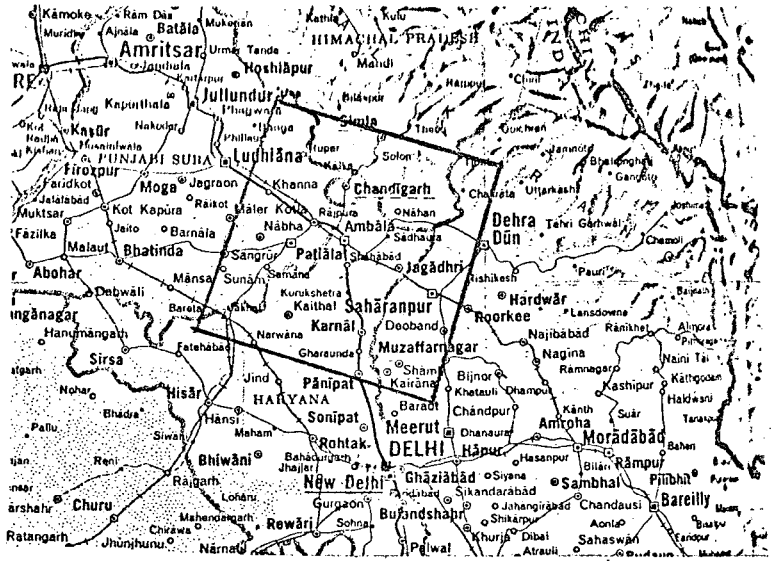

FIGURE 2

1:6,000,000 MAP OF NORTHWESTERN INDIA
SHOWING LOCATION OF FRAME 1043-04562

brighter because their higher elevation and consequent reduced path radiance, and increase atmospheric transmission, and incident irradiance.

The area chosen for intensive study is an area of small field agriculture interspersed with forests, sand dunes, and irrigation canals. (The sand dunes are the darkest features in Figure 1, and the reader may use them in correlating the imagery with the recognition map to be presented later.) The agriculture consists primarily of corn and pulses (legumes) grown in small, irregularly-shaped fields. The forests are found in lowlands along irrigation canals and rivers. The sand dunes are areas of dry sandy soil unsuitable for agriculture.

3.0 PROCESSING DESCRIPTION

ERTS-1 MSS bulk digital tapes were processed on the ERIM 7094 computer, using pattern recognition software previously developed. The general flow of processing operations is shown in Figure 3. Tapes were first copied to the ERIM format for further processing. Then a map of band MSS-5 was prepared to assist in locating training sets for further digital analysis. This map was found useful for locating two different categories of forest, two different types of agriculture, two different bare soil types, and the sand dunes. Water training sets for further analysis were easily located on graymaps of band MSS-7 made of a small portion of the intensive study area data.

Several samples of each class to be recognized were selected, and spectral signatures obtained. By selecting samples of each class, the range of intra-class variability can be more precisely delineated. Spectral signatures of the individual samples may then be combined to yield a close approximation to the spectral signature of the class to be recognized. At the signature analysis

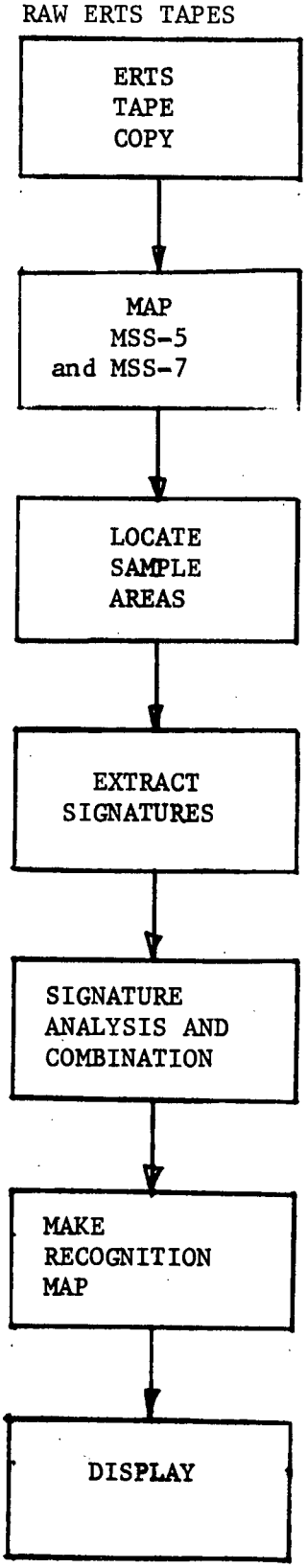
RAW ERTS TAPES
ERTS TAPE COPY
MAP MSS-5 and MSS-7
LOCATE SAMPLE AREAS
EXTRACT SIGNATURES
SIGNATURE ANALYSIS AND COMBINATION
MAKE RECOGNITION MAP
DISPLAY

FIGURE 3

stage, some samples of each class were rejected as being non-representative. The criterion for rejection included 1) means sizably different from the means of the other samples in the class, and 2) large signature standard deviations in one or more channels.

After creating the class signatures by combining appropriate sample signatures, the data were classified. The classification rule is a linear approximation to the maximum likelihood ratio rule. This approximation has yielded good results (nearly indistinguishable from the results of the maximum likelihood ratio rule) on other aircraft and ERTS-1 multispectral data sets.

Recognition results were then displayed in four colors to yield the color-coded recognition map shown in Figure 4. At the color mapping stage, an editing criterion was imposed so that points not resembling any of the training sets selected were printed as white (not classified).

4.0 DISCUSSION OF RESULTS

The map shown in Figure 4 is being analysed by Dr. Sharma in India. Although this phase of checking of the results is not complete, some preliminary analysis results are presented here.

The water recognition accurately portrays the reservoir (blue S shaped feature in the lower center of Figure 4). Also recognized as water are a large area in the lower right center which is probably an inundated forest area and numerous small scattered areas, particularly in the lower left of the figure. These latter features are felt to be ephemeral ponds caused by a heavy monsoon rain which fell in the area a few days before the data were

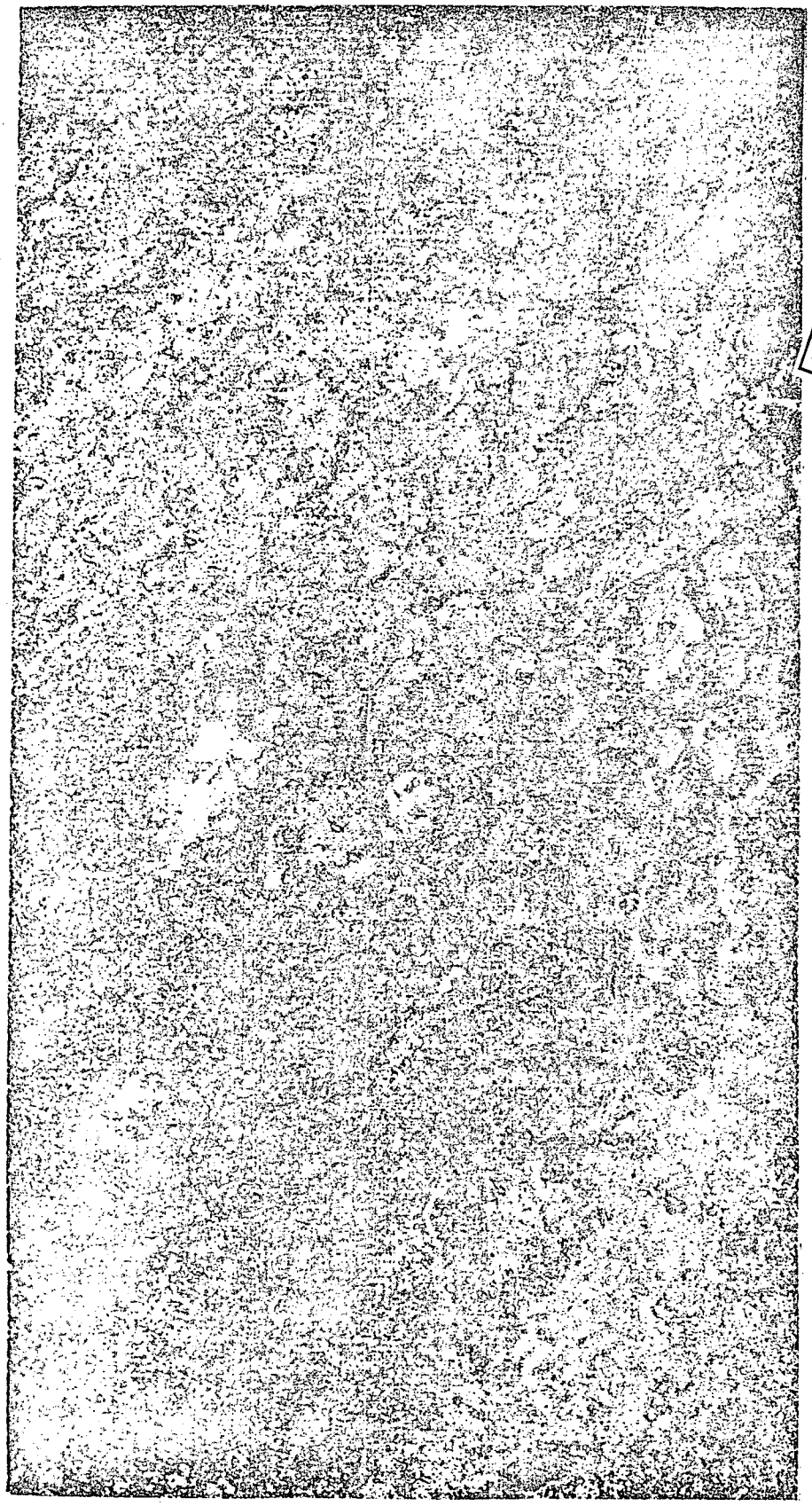

FIGURE 4a

COLOR CODED RECOGNITION MAP OF
INDIA AGRICULTURE AREA

KEY FOR CLASSIFICATION MAP OF ERTS PUNJAB FRAME

4 September 1972

Color	Symbol	Object Class
Black	▩	Forest 1
	*	Forest 2
Blue	▩	Water
Green	▩	Corn
	*	Pulses (Legumes)
Red	▩	Sand Dunes
	▩	Bare Field 1
	*	Bare Field 2

FIGURE 4b

COLOR CODE FOR DIGITAL RECOGNITION MAP

collected. (Occurance of this rain was verified by Dr. Sharma who was in India at the time.)

Sand dune areas are also apparently accurately portrayed. This was verified by comparing the boundaries of sand dune areas with the boundaries derived by photointerpretation of the red band (MSS-5) imagery. Good qualitative agreement was found.

Forest areas seem to be fairly well recognized. Although not apparent from the figure, most canals are delineated as a thin band of forest recognition corresponding with the location of canals on large scale Army Map Service Maps.

Bare soil and agriculture categories require field checking before even qualitative statements about accuracy can be made.

5.0 CONCLUSIONS

This exercise has so far demonstrated that qualitatively good recognition maps can be prepared from ERTS-1 MSS data that have first been tape recorded on the spacecraft, then telemetered to the ground. Further analysis is expected to show that while large terrain features are accurately classified, the accurate recognition of small agricultural areas is compromised by the fact that typical field sizes are on the order of one ERTS-1 resolution element in size.

For an accurate assessment of the agricultural resources of such an area, processing techniques capable of estimating proportions of unresolved objects should probably be used. Such techniques have recently been discussed by Nalepka [1].

REFERENCES

1. R. F. Nalepka, et al., "Estimating Proportions of Objects from Multispectral Data", Infrared and Optics Laboratory, Willow Run Laboratories of the Institute of Science and Technology, University of Michigan, prepared for National Aeronautics and Space Administration, Contract NAS 9-9784, NASA CR-WRL 31650-73-T, March 1972.